GTI Combustion Technologies for the Industry

> by

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Presentation Outline

- What is GTI?
- Commercially available technologies
- Technologies under development
- Planned developments

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GTI

- Leading U.S. research, development and training organization serving energy and environmental markets
- Headquarters: Des Plaines, IL
  - 300,000 sq-ft facility on an 18-acre campus
  - Laboratories, test facilities, library, offices
- Staff: 340
- Contract research, development, and demonstration projects

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Combustion Research Facilities

- Over 20,000 sq-ft facilities housing a wide range of test equipment and instrumentation
  - Boilers and boiler simulators
  - Pilot and full scale industrial furnaces
  - Residential-commercial laboratory
  - Gas turbine and reciprocating engine R&D
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Commercially Available Technologies

- Oxygen-enriched air staging *
- FIR burner for boilers and radiant tubes*
- Oscillating combustion for oxy-gas furnaces*
- METHANE de-NOX for stoker boilers*
- High luminosity oxy-gas burner for fiberglass furnaces*
- Ceramic radiant tubes

*Developed with support from DOE

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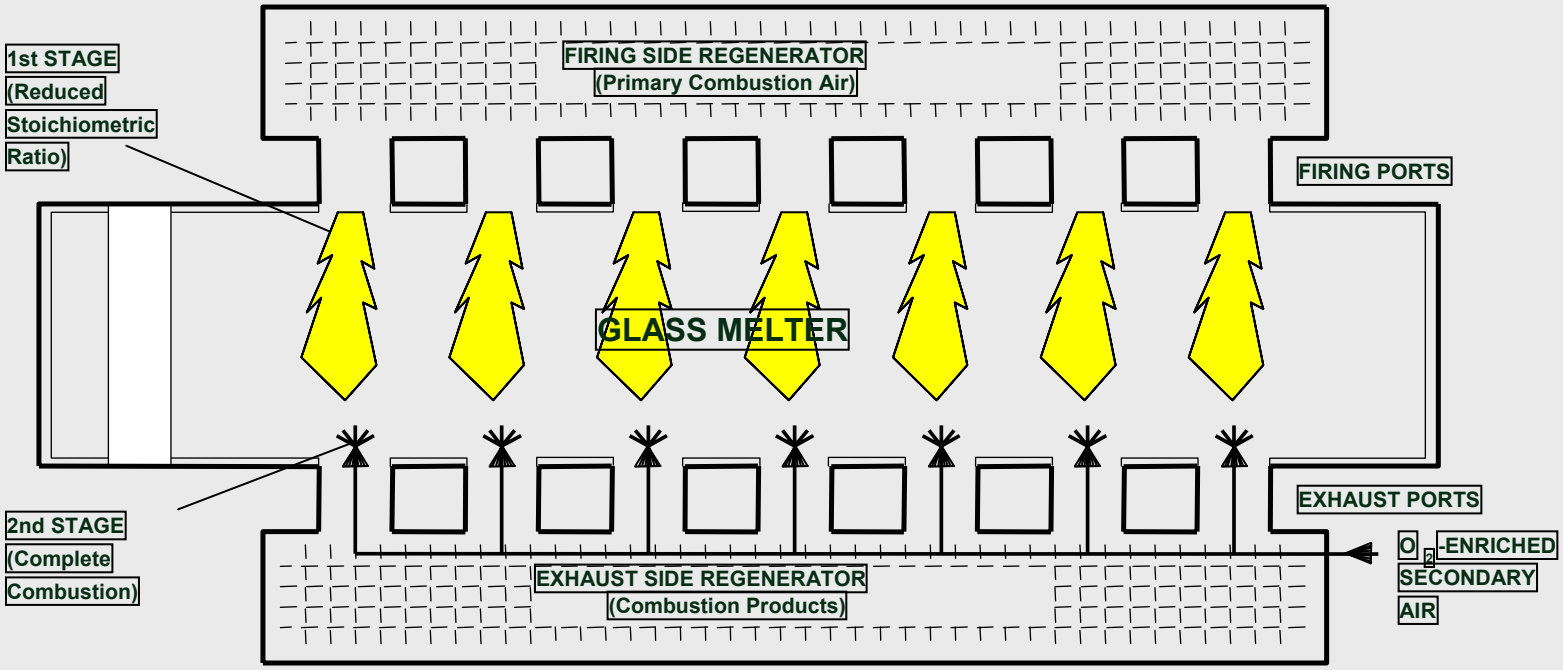
Technologies Under Development

- Other applications for commercial technologies
- Thermal Imaging Control* – ready for field evaluation
- Self Optimizing Combustion system
- Gas –Fired paper dryer
- Direct flame impingement heating*
- Superboiler*- component testing
- Dimple heat exchanger*
- Indirect-fired flat radiant panel – ready for field evaluation

*Developing with support from DOE

Oxygen Enriched Air Staging

- Key feature: Low cost NO_x reduction for industrial furnaces
- Applications: Glass melting, steel reheat, process heaters?
- Partners: Eclipse Combustion, end users
- Sponsors: DOE OIT, GRI, SoCal Gas, SMP

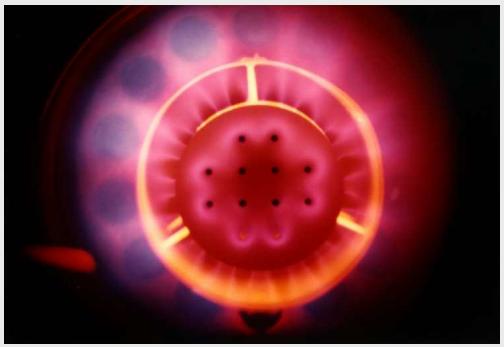


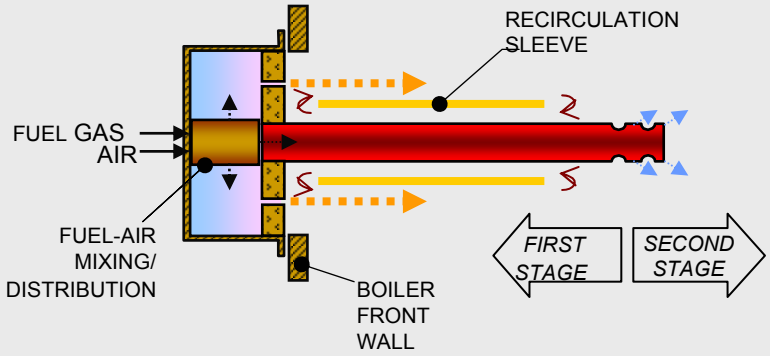
OEAS Status

- Commercialized for container and flat glass furnaces
  - twelve installations, several sales in process
- Future activities: Expand application to other furnaces

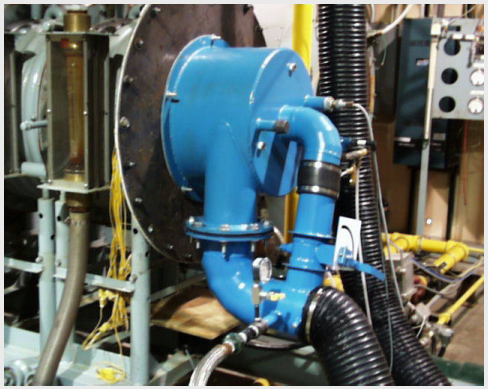
FIR Burner for Boilers and Process heaters

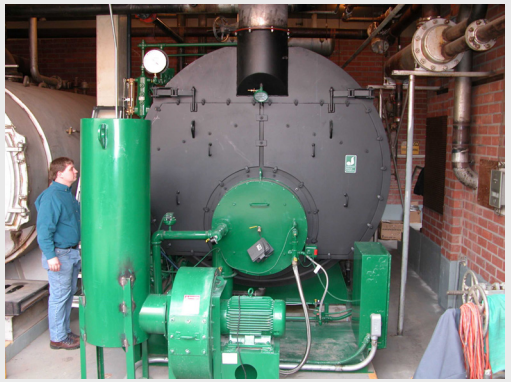
- Key Features: Sub 10/15 vppm NOx (NGas/ Mixed steel industry fuels) with low excess air and w/o FGR
- Applications: Commercial and industrial boilers and water heaters, and process heaters
- Partners: Johnston Boilers, COEN, Peabody Engineering, end-users
- Sponsors: DOE OIT, GRI, SoCal Gas, SMP





FIR Burner Status



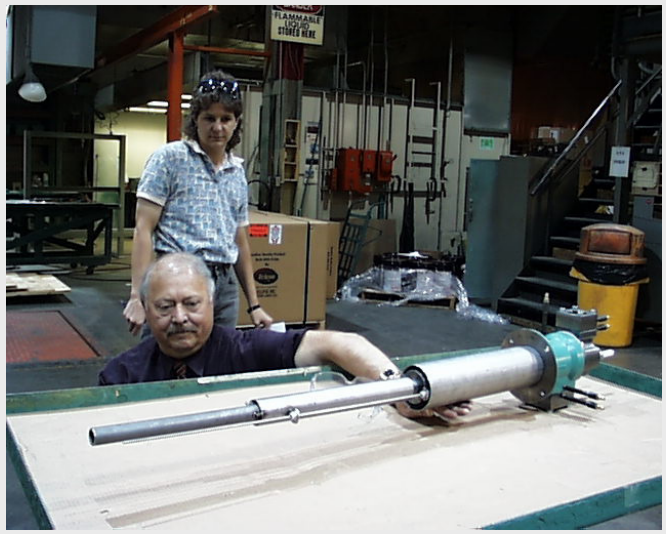


- Field evaluated at Miller Brewing and vandenberg AFB achieving below 10 vppm and below 15 vppm respectively
- Both burners in operation since 2000
- Sold two 10.5 MM Btu/H commercial units to Fullerton College, CA
- First already in operation with below 10 vppm NOx

Commercially available for ngas fired firetube boilers. Currently expanding to watertube boilers to fire oil and mixed gaseous fuels and to reduce NOx below 5 vppm,

High Performance Radiant Tubes

- Key Features: Ultra low NOx emissions and uniform tube temperature
- Applications: Heat treating furnaces, other radiant tube furnaces
- Partners: Eclipse Combustion
- Sponsors: GRI, SoCal Gas, SMP, NYGAS, CARB

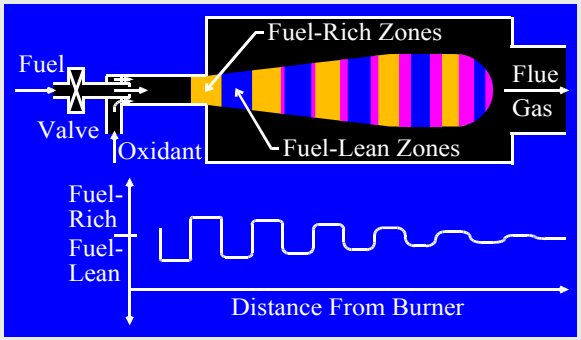


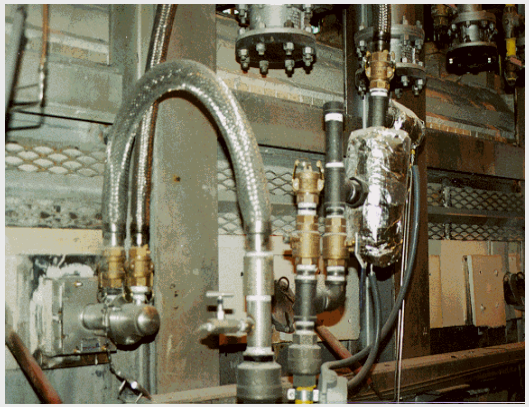
High Performance Radiant Tube Status

- proved performance on a 4 inch diameter tube on GTI's heat treating lab furnace
- Currently being installed for field evaluation testing at ITW CIP Stampings in Santa Fe Springs, CA

Oscillating Combustion

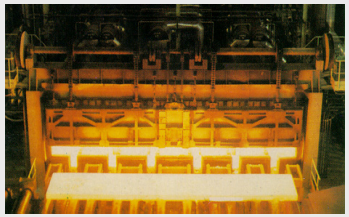
- Key features: Inexpensive valve/controller retrofit to conventional burners increases heat transfer by 5%+, and reduces NOx by 30-70%
- Applications: Glass melters, forging, steel reheat, cement/lime kilns, etc.
- Partners: Air Liquide, Synergistics Partners, end users
- Sponsors: DOE OIT, GRI, SMP, SoCal Gas, Columbia Gas

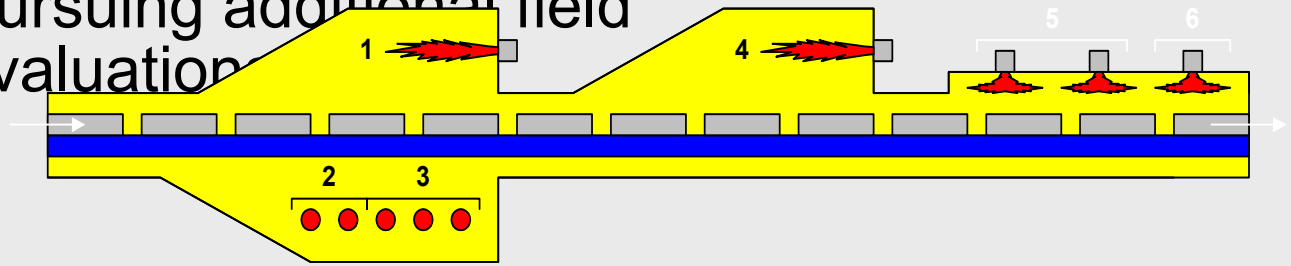




Oscillating Combustion Status

- Converted Johns-Manville 150-ton/d borosilicate oxy-gas fiber wool melter for field evaluation
  - 55% NO_x reduction
  - 30°- 50°F drop in crown temperature
  - 3% fuel, 7% O_2 savings
  - no impact on glass quality
- Pursuing additional field evaluation





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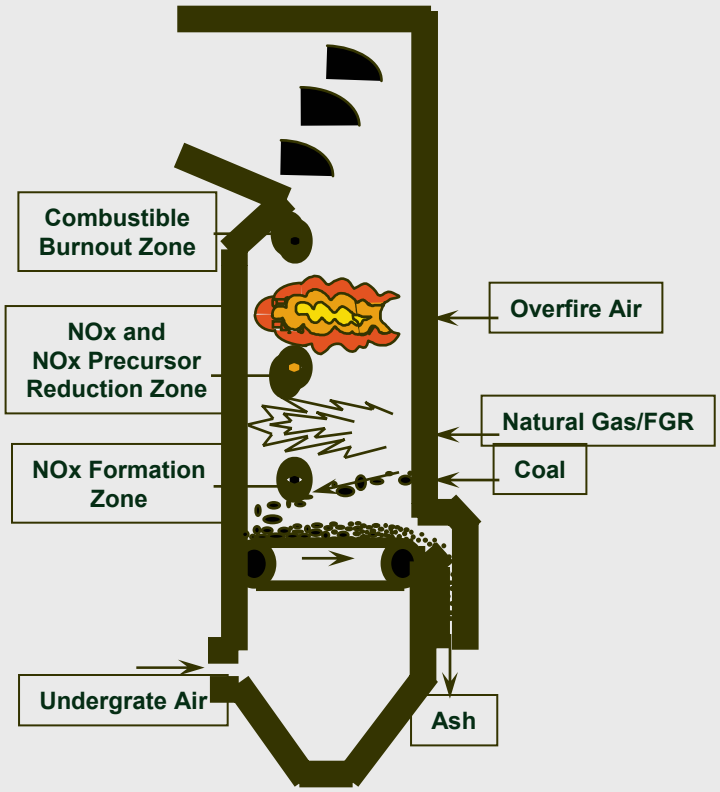
METHANE de-NOX

- Key Features: Uses 10% natural gas to reduce NOx by 50% and increase efficiency by 2%
- Applications: Stoker-fired MSW, biomass, and coal boilers
- Partners: ESA (USA), Takuma Company (Japan), end users
- Sponsors: GRI, DOE OIT, SMP, SoCal Gas, several other gas utilities

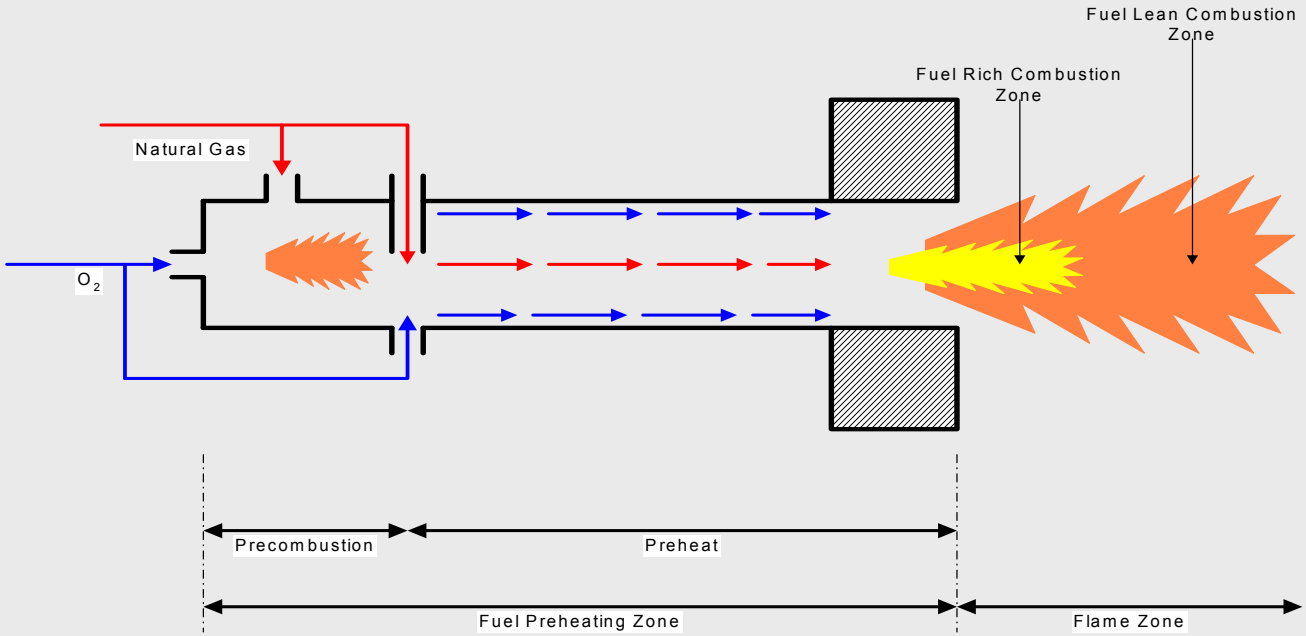


METHANE de-NOX Status

- Converted eight coal-fired boilers at Cogentrix, including seven sales
  - received R&D 100 award
- Field evaluated on a wood-fired stoker at Boise Cascade
  - unit is in continuous operation
  - received AFPA award
- Currently installing on several wood fired and coal fired stoker boilers and testing use of NCGs as reburn fuel

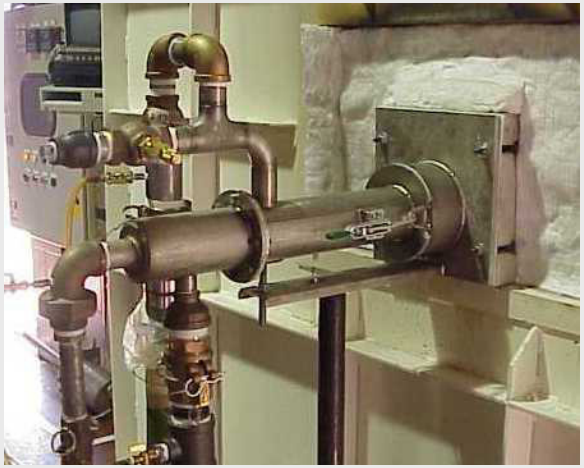
High Luminosity Oxy-Gas Burner

- Key features: Reduces NOx and increases efficiency of oxy-gas systems
- Applications: High temperature furnaces
- Partners: Eclipse Combustion, Owens Corning, PPG
- Sponsors: GRI, DOE OIT, SMP, NYSERDA



High Luminosity Oxy-Gas Burner Status

- Proved performance in the laboratory at 0.5 and 2 MMBtu/H scales
- Field evaluated on an Owens Corning fiber glass and a PPG flat glass furnace through partial conversion
- Future activities: complete testing of full conversion, expand applications and develop commercial designs



Thermal Imaging Control of Processes

- Key feature: Uses furnace/oven interior temperature maps for combustion and process control
- Applications: Medium to High temperature furnaces
- Partners: IEM,UIC
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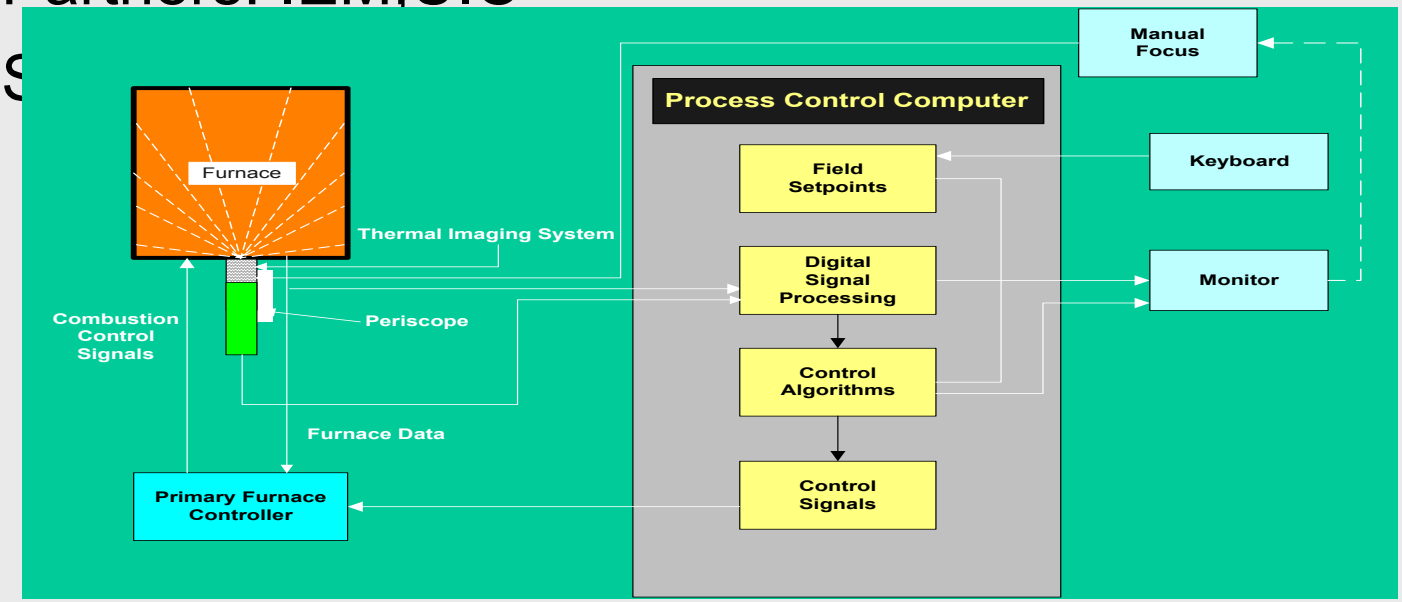
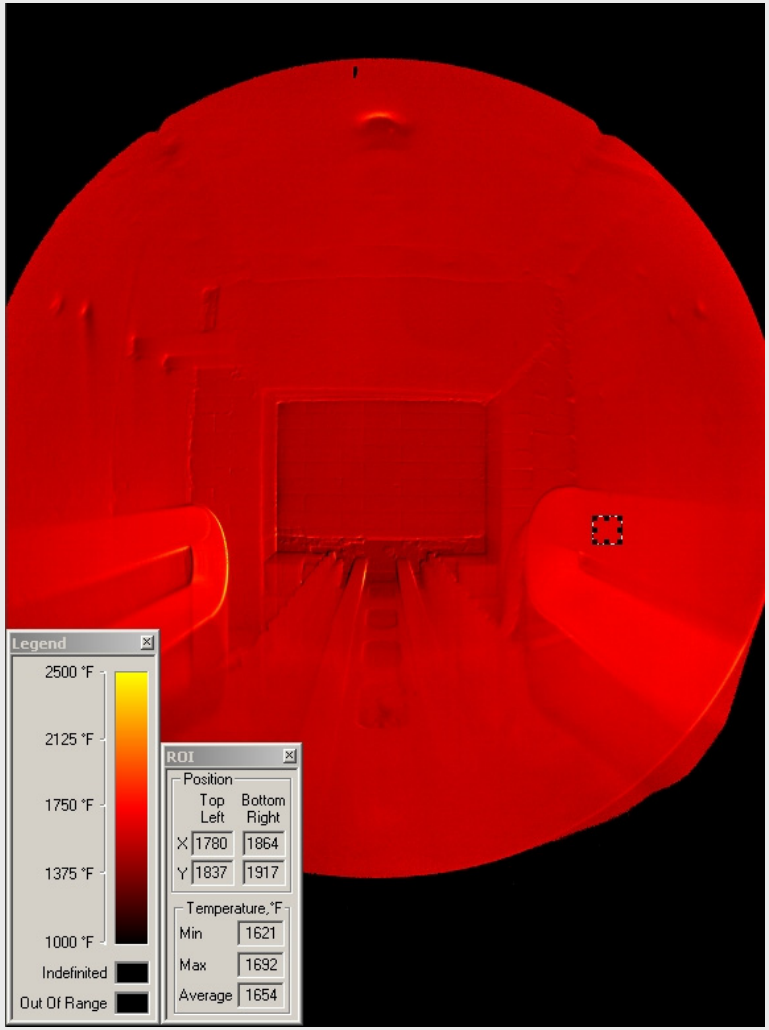


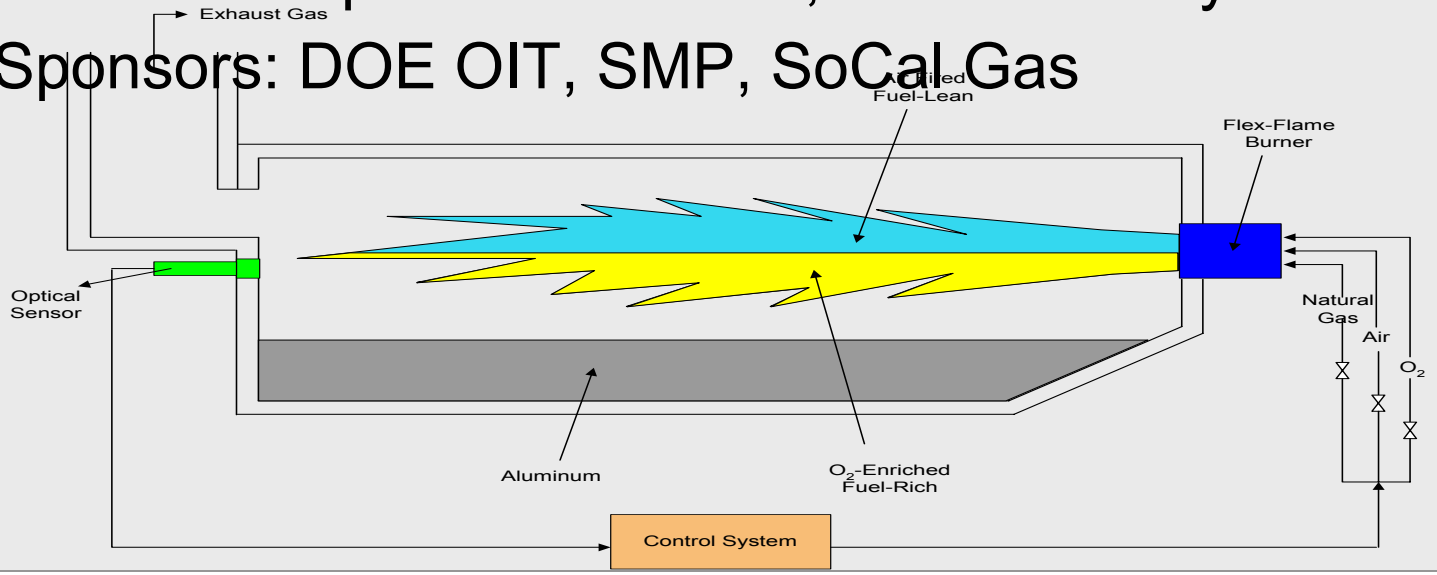
Thermal Imaging Control Status

- Proved imaging capability on a bench scale
- Developed control algorithms and proved concept on a heat treat lab furnace
- Future activities: test prototype unit on a commercial furnace



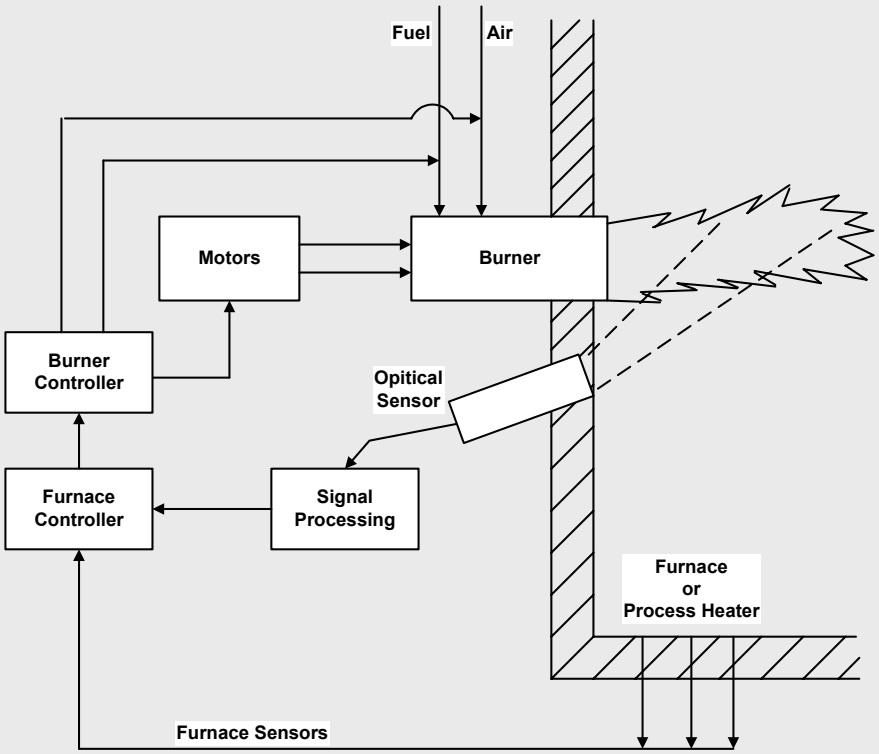
Self Optimizing Combustion System

- Key features: Automatically adjusts flame characteristics to match process requirements, reduces NOx, minimizes metal oxidation, and increases production rate
- Applications: Metal melting/ heating furnaces, and fluid heaters
- Partner: Eclipse Combustion, Wabash Alloys
- Sponsors: DOE OIT, SMP, SoCal Gas



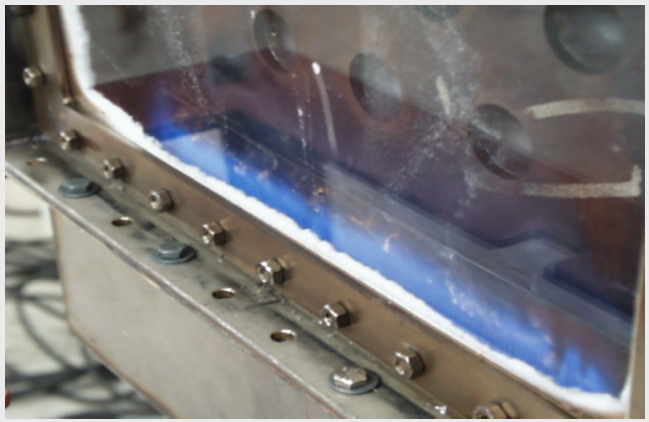
SOCS Status

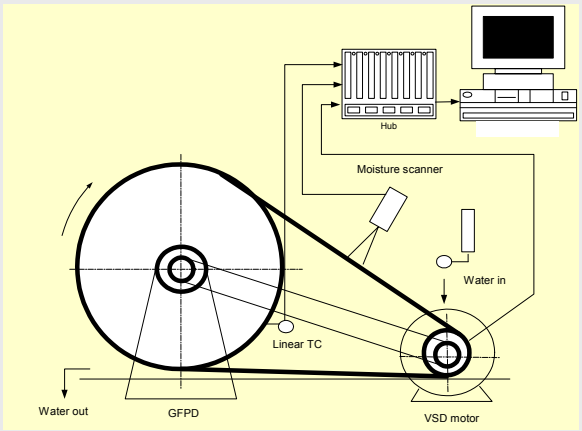
- Status:
  - Completed bench scale tests
  - Undergoing lab tests at GTI on a pilot scale burner
- Future activities:
  - Complete lab tests at GTI and test performance on an aluminum melter



High Capacity Paper Dryer

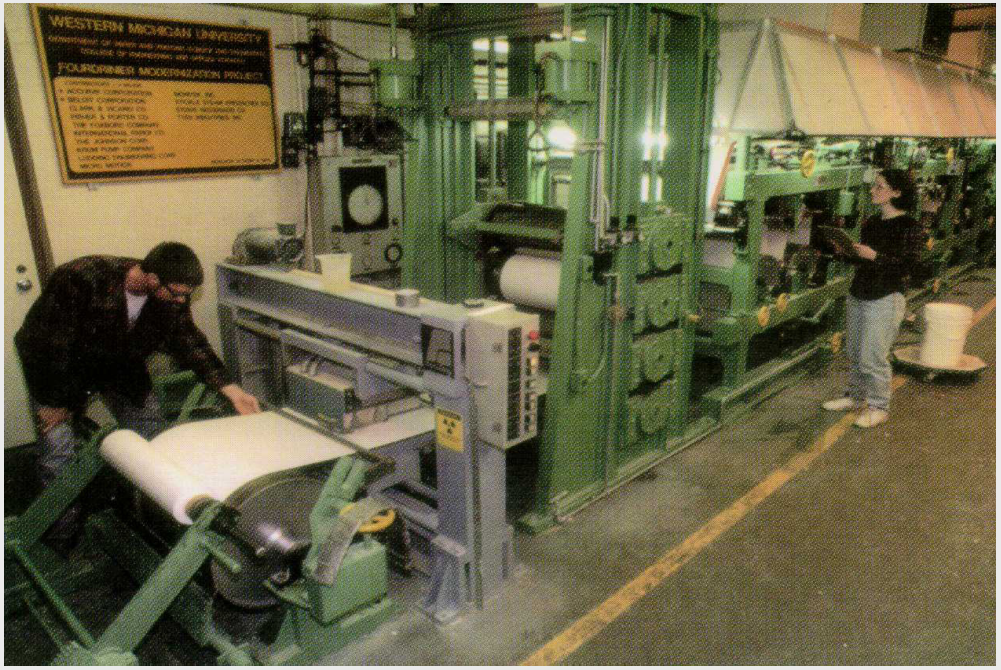
- Key features: Increase production rate using existing machines while increasing efficiency and reducing NOx
- Applications: Paper drying
- Partners: GL&V/ Black Clawson-Kennedy, Boise-Cascade, Flynn Burner Corp, WMU, Purdue U
- Sponsors: GRI, DOE OIT, SMP





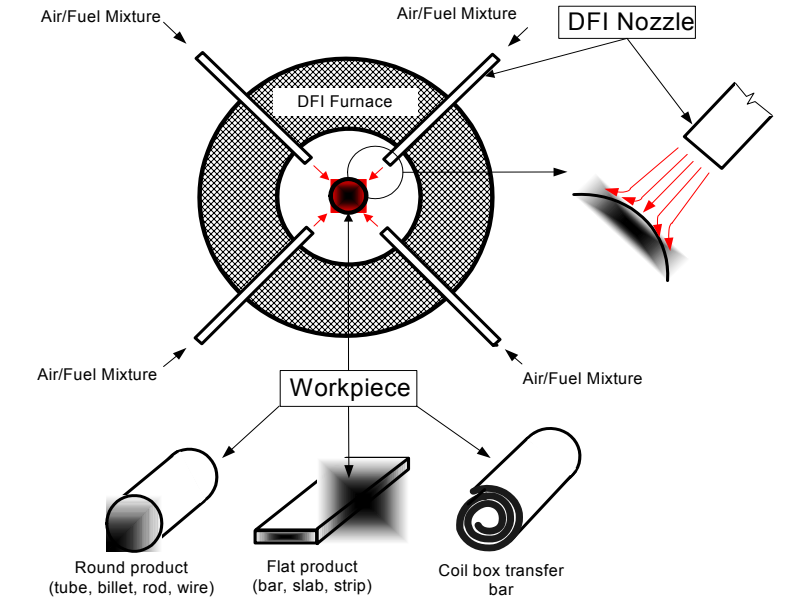
High Capacity Paper Dryer Status

- Tested performance in the laboratory at a bench scale
- Designed pilot scale dryer drum for testing at GTI and WMU
- Future activities: test performance at GTI and at WMU pilot paper machine, seek support for full scale testing at a paper mill



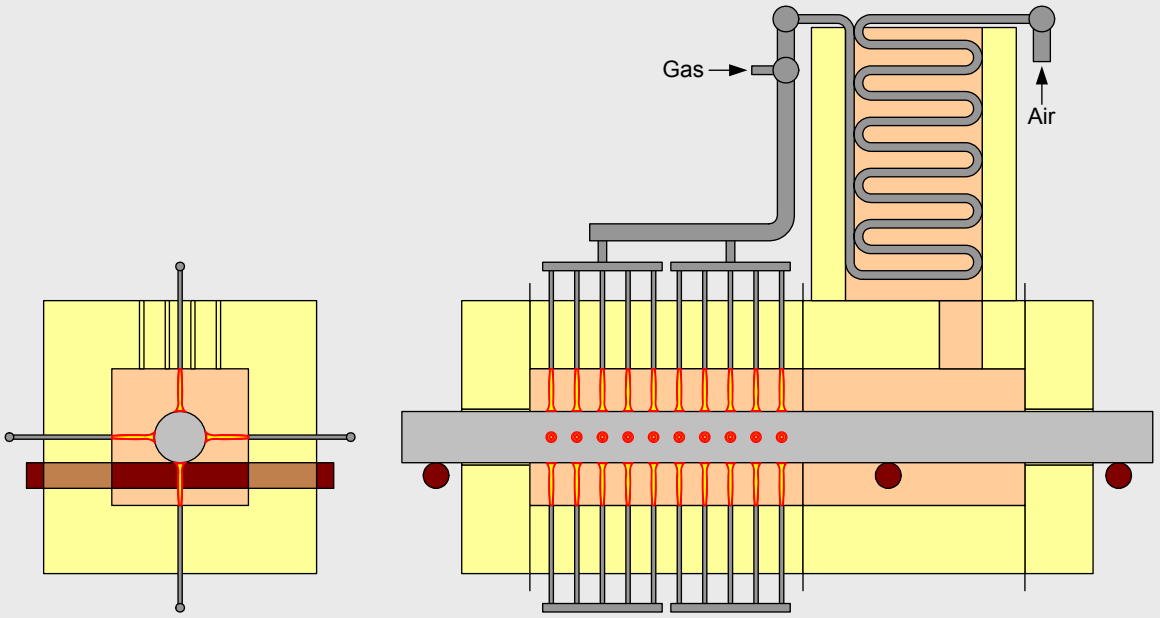
Direct Flame Impingement Heating

- Key feature: Direct flame impingement heating provides improved efficiency, fast startup,NOx below 50 vppm, and longer refractory life
- Applications: Heating of square, round and flat metal shapes
- Partners: NA Manufacuring Co, NA Furnace Co, Bethlehem Steel, Geneva Steel, Timken, RAES
- Sponsors: DOE OIT, GRI, SMP



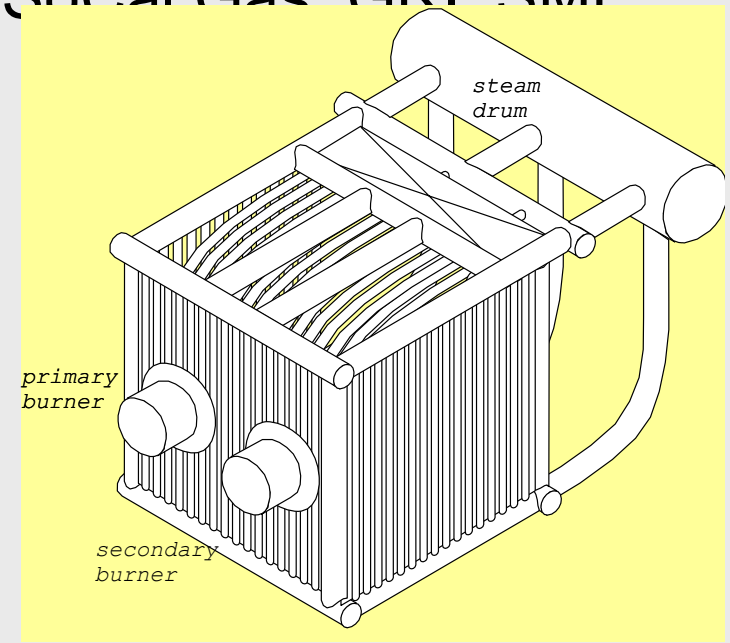
DFI Status

- Pilot scale furnace under construction for lab testing at GTI
- Future activities: complete lab testing, test at industrial site(s) through partial retrofit



Super Boiler

- Key features: <5 vppm NOx, <20 vppm CO/THC, >94% efficiency, 50% smaller footprint and weight, longer life
- Applications: Industrial and commercial facilities
- Partners: Cleaver Brooks, ABMA
- Sponsors: DOE OIT, SoCal Gas, GRI, SMP



Super Boiler Status

- Combustion, heat-transfer and condenser concepts lab tested
- First generation Superboiler designs developed, and a 5 mm Btu/H boiler is under construction for lab testing at GTI
- Superboiler 2020 RD&D plan under development
  - Create the framework of a long-range program for innovative crosscutting steam generation R&D
  - Assemble an industrial advisory group
- Future: complete lab and subsequent field testing and finalize 2020 R&D plan

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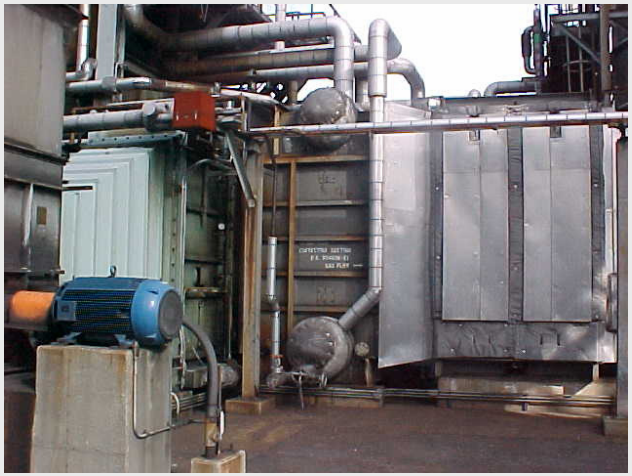
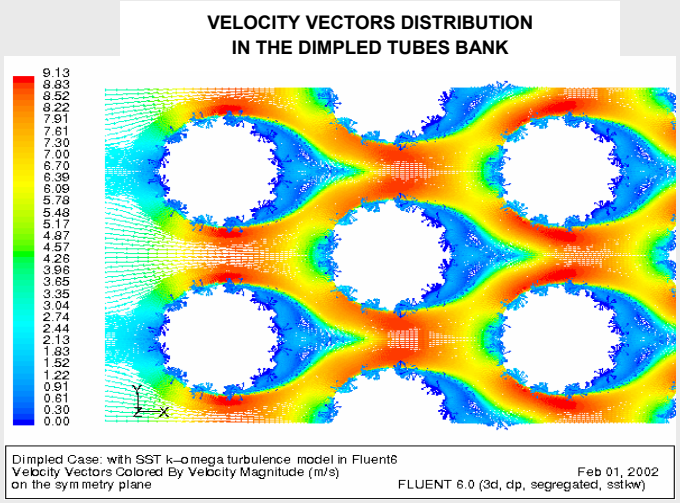
Enhanced Heat Exchangers for Process Heaters

- Key features: Increase efficiency of process heaters without increasing pressure drop
- Applications: Process heaters
- Partners: BP, Exxon Mobil, KTI corp
- Sponsors: GRI, DOE OIT, SMP

Enhanced Heat Exchanger Status

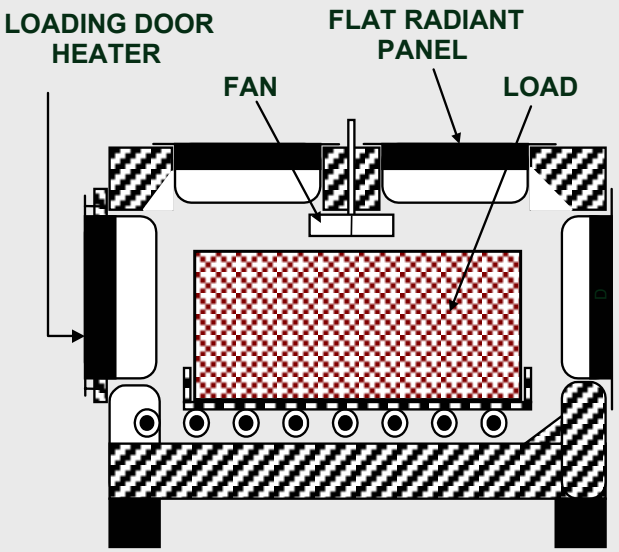
- Completed CFD modeling to assist with heat exchanger tube design
- Constructed pilot scale heat exchanger
- Future activities: Test pilot unit at GTI, scale up and test performance by retrofitting a convective pass section at Cherry Point Refinery





Flat Radiant Panel

- Key features: Internally recuperated, uniform temperature, low NOx, indirect-fired
- Applications: hest treating, paint drying, food processing
- Status: successfully tested a 1.2MM Btu/h, 1600°F furnace equipped with 6 FRPs and tested a 2000°F FRP, seeking field testing site



Recently Initiated and Planned Developments

- Partial oxidation gas turbine for power and H_2-rich gas production
- Combustion temperature, composition* sensors
- Ultra low emissions and high efficiency engine systems
- Measurement and characterization of ultra-fine particulates
- Catalysts/ sorbents for air toxics control
- Food processing technologies
- IR heaters

*Developing with support from DOE